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13. ABSTRACT (Maximum 200 words) The objectives of this program were to develop a comprehensive understanding of ongoing government-sponsored environmental R&D activities important to the development of new ARPA program efforts in Environmental Science, and to assess the potential for integration of environmental concerns in the design, manufacture, and performance of defense systems, pertinent to incorporating environmental life-cycle considerations into the development of military systems and equipment. This included: (a) development of an electronic database which includes the major R&D activities sponsored by the government in the area of environmental science; (b) investigation of key methods being attempted by industrial concerns to incorporate environmental considerations into the design, manufacture, and performance of major products; and (c) recommendations on new defense efforts which incorporate such environmental considerations into the development cycle of new systems.				
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**ASSESSMENT OF ENVIRONMENTAL SCIENCES R&D AND ITS POTENTIAL
IMPACT ON THE DESIGN, MANUFACTURE, AND PERFORMANCE OF
DEFENSE SYSTEMS**

FINAL REPORT

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22 APRIL 1996

U. S. ARMY RESEARCH OFFICE

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1.0 PROGRAM OBJECTIVES

The objectives of this program were to develop a comprehensive understanding of ongoing government-sponsored environmental R&D activities important to the development of new ARPA program efforts in Environmental Science, and to assess the potential for integration of environmental concerns in the design, manufacture, and performance of defense systems, pertinent to incorporating environmental life-cycle considerations into the development of military systems and equipment. This included:

- Development of an electronic database which includes the major R&D activities sponsored by the government in the area of environmental sciences.
- Investigation of key methods being attempted by industrial concerns to incorporate environmental considerations into the design, manufacture, and performance of major products.
- Recommendations on new defense efforts which incorporate such environmental considerations into the development cycle of new systems.

2.0 KEY RESULTS OF THE PROGRAM

2.1 Database of Government-Sponsored Environmental Sciences

R&D: An interactive database of government-sponsored environmental R&D efforts was developed in FoxPro for Windows. This database is comprised of two modules: the data entry module, and the query module. This database enables the user to rapidly search for ongoing or recent efforts by key words, investigator, and sponsor. Copies of the software and associated user documentation are provided to the ARO and ARPA sponsors for their internal use. (Copies provided to ARO and ARPA only).

At present, the database is comprised of over 500 entries of government-sponsored projects in the area of Environmental Sciences R&D. Although a broad range of agencies are represented, the largest proportion of projects that are currently active are sponsored by the Department of Energy (DOE) and by the Department of Defense (DoD).

The Environmental Sciences R&D Database contains information on federally-funded environmental sciences R&D projects and programs. The following information is provided for each project:

- | | |
|------------------------|---------------------------|
| • Project Name | • Stage of Development |
| • Program | • Potential Applicability |
| • Principal Objectives | • Summary Description |
| • Project Deliverables | • Period of Performance |
| • Keywords | • Funding |
| • Material Type(s) | • Status |
| • Specific Materials | • Information Source |
| • Major Category | |
| • Environmental Media | |

In addition to project information, the Environmental Sciences R&D Database contains information about Department/ Agency Sponsors and Performers associated with each project.

Department/Agency Sponsor

Performers

- | | |
|--------------------------------|--------------------------------|
| • Sponsor Organization | • Organization |
| • Point of Contact Information | • Address |
| • - Name | • Point of Contact Information |
| • - Title | • - Name |
| • - Organization | • - Title |
| • - Phone | • - Phone |
| • - Fax | • - Fax |
| • - E-mail | • - E-mail |

The above information are fields located in the Environmental Sciences R&D Database. A field refers to one piece of information within a record, and a record refers to a complete set of information comprised by all fields combined within a particular database. The information is contained in three relational databases:

- ① Project Database - contains information regarding project;
- ② Department/Agency Sponsor Database - contains information regarding Department/ Agency Sponsor point of contact; and
- ③ Performers Database - contains information regarding Performer point of contact.

2.2 Study of Industrial "Best Practice": A stepwise approach to developing the capability of integration of environmental concerns to the development of future systems was discovered at BMW, in Germany. This approach is the most forward-thinking one discovered in a broad search of ongoing efforts in the industrial sector.

The BMW Initiative

Due to "green" laws that pervade the German economy, the last owner of automotive vehicles is responsible for proper recycling, which is ensured only if the used vehicle is turned in to a recycling company that is licensed and has approved recycling methods. BMW has undertaken considerable efforts to first develop a strategy for recycling as much as possible (from both a practical and economic standpoint) from automobiles produced by the company, and second, for evolving methods of incorporating environmental considerations into future automotive designs. This systems approach has been undertaken to implement life-cycle thinking, and is rare, if not unique, in industrial practice.

In 1990, BMW became the world's first car maker to establish an in-house pilot dismantling plant, and a Recycling Department. Under its leadership, the German Car Industry Project Group for the Recycling of Old Cars (PRAVDA) was established, involving all German car makers in a cooperative effort which deals with both the

technical/economic and political issues involved in recycling of old cars. In 1994, BMW established its new Recycling and Dismantling Center (RDC) in Lohhof (near Munich), with the objective of avoiding residues or waste from reutilization of old cars to the largest possible extent, by first reconditioning and recycling old components, and by reuse of materials from old components to produce new components and parts. The methods developed at the RDC are certified and licensed to recycling companies recognized by the German government as operating under best recycling practices, thus closing or significantly upgrading facilities that were previously "junkyards".

The process which is being followed at this time involves four steps: First, all operating fluids (oil, coolant, brake fluid, fuel, etc.) and the battery is removed from each car; these materials then enter into commercial waste stream recycling operations similar to those established in the US. Second, valuable parts and components (engine, transmission, alternator, etc.) are removed and sent to certified recyclers, where they rebuilt for the parts market. Third, materials (metals, plastics, glass, seat foams, tires) are removed and segregated, especially by polymer class. The materials are shredded, and mechanical separation of ferrous and nonferrous metals is accomplished. Fourth, the materials which are residual from the shredding process historically deposited in waste sites, are either recycled chemically or used for energy recovery if they have high energy content. In this regard, they have substantial market as alternate fuel for industrial plants.

Several key innovations have occurred which have made the recycling process more efficient and therefore more economically feasible. A major development has been the adaptation of IR spectroscopy to real-time characterization of plastic parts to assure their composition. This is important, since many components are made of multiple types of plastic, and since there are many plastics in use throughout the automobile. This has also led the company to develop new automotive designs which involve a reduced variety of plastics. Refractory and precious metals (including platinum and rhodium) are regained from used catalytic converters. Glass is recycled into new cars and into glass panels for

building construction. Special fluids recycling work cells have been developed in and capture all fluids - these work cells are now marketed to recyclers by BMW, who also train and certify the technicians. A data acquisition package named CAR-IT has been developed for processing dismantling data, including the time involved to dismantle various components, in order to focus new car design efforts to make components more recyclable. Substantial efforts have been made to recover energy from waste materials using incineration with optimized purification of flue gas and cogeneration of heat. R&D efforts include high temperature gasification for chemical recycling/energy recovery, which are regarded as the best options for ecological and economic efficiency.

Based upon this substantial base of new knowledge, BMW has established a new approach to new car development, taking environmental concerns into account:

1. Definition Phase - In addition to defining the vehicle in terms of market, performance characteristics, etc., ecological targets are determined in concert with technical and economic requirements.

2. Concept Development Phase - Conducting a life-cycle analysis and applying an energy balance, this phase allows an initial ecological assessment of different parts and components concepts, also taking economic factors into account. Various methods are utilized, including a dismantling analysis, providing important information on materials, joining technologies, the work content involved in dismantling and separation, and the tools and ancillary equipment, such as new characterization equipment, required for this process. Commitment to development of a new series of automobile does not occur until the ecological, technical and economic aspects of the design are complete and satisfactory.

Potential for Application to Life Cycle Design of DoD Systems

The "industrial best practice" described at BMW has taken an evolutionary approach to the establishment of the requisite database on materials and markets for recycling and reuse of the materials of interest to the automotive industry. In order for DoD to leverage

such an experience base, it should develop targeted classes of systems for which a similar project could be established. For aircraft systems, key materials such as titanium and aluminum are in major use; polymer composites are emerging into new systems based upon their structural requirements as well as the requirements for light weight and reduced signature. This is becoming increasingly true for ground vehicle systems, as well.

The AMC Polymer Matrix Composite Assessment, authored by Crowson and Hagnauer, establishes the basis for a more comprehensive look across military systems requirements for polymer matrix composites, and should serve as a leaping off point in terms of establishing an initiative for life cycle considerations in the design, manufacture, and service life requirements of ground and air vehicles for the Army. Taking the BMW approach as a framework for establishing the capability to recycle or reuse polymer matrix composites, focused upon Army vehicles, would be a key pilot project for establishing a new strategy for dealing with such concerns for current and future military vehicles. Perhaps an Army Science Board assessment study should be instituted to evaluate this as an Army initiative.

Recommendations for DoD efforts: It would be possible to first transition the BMW approach, suitably modified to incorporate defense concerns and procurement practices, to establish a comprehensive approach to recycling defense systems, starting initially with a pilot effort on either mothballed air or ground vehicles, with a goal of transition to electronic systems in the near future, while developing a more comprehensive strategy for green designs of systems which incorporate life-cycle thinking. In that regard, it would be feasible to develop a joint project with the German military to develop and institute a facility for recycling and dismantling of ground or air vehicles, with the objective of starting with current systems, but moving over several years to incorporation of life cycle approaches to ground and air vehicles which will increasingly demand the usage of polymers and composite materials.

3.0 PUBLICATIONS AND TECHNICAL REPORTS

Environmental Sciences R&D Database Users Guides - Data Entry and Query Modules.

4.0 PARTICIPATING SCIENTIFIC PERSONNEL

BDM:

Dr. Phillip A. Parrish, Mr. Jeff Hendrix, Mr. Ken Thurman, Mr. Ken Keasler.

Consultants:

Dr. William E. Snowden, Ms. Ellen Solos.

5.0 REPORT OF INVENTIONS

None.

**ENVIRONMENTAL SCIENCES
RESEARCH & DEVELOPMENT DATABASE
(ESRD DB)**

User's Guide

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1.0 Introduction

Welcome to the Environmental Sciences Research & Development Database (ESRD DB). This product was developed by BDM Federal, Inc. to support the Advanced Research Projects Agency (ARPA) and the Army Research Office (ARO).

The ESRD DB was developed using FoxPro for Windows (version 2.6) and compiled as a stand-alone application using the FoxPro Distribution Kit (version 2.6). The executing program is called **esrd_db.exe**.

The ESRD DB contains information on federally-funded environmental sciences R&D projects and programs. The following information is provided for each project:

- | | |
|------------------------|---------------------------|
| • Project Name | • Stage of Development |
| • Program | • Potential Applicability |
| • Principal Objectives | • Summary Description |
| • Project Deliverables | • Period of Performance |
| • Keywords | • Funding |
| • Material Type(s) | • Status |
| • Specific Materials | • Information Source |
| • Major Category | |
| • Environmental Media | |

In addition to project information, the ESRD DB contains information about Department/ Agency Sponsors and Performers associated with each project.

Department/Agency Sponsor

- Sponsor Organization
- Point of Contact Information
 - Name
 - Title
 - Organization
 - Phone
 - Fax
 - Email

Performers

- Organization
- Address
- Point of Contact Information
 - Name
 - Title
 - Phone
 - Fax
 - Email

The above information are fields located in the ESRD DB databases. A field refers to one piece of information within a record, and a record refers to a complete set of information comprised by all fields combined within a particular database.

The information is contained in three relational databases:

- ❶ Project Database - contains information regarding project
- ❷ Department/Agency Sponsor Database - contains information regarding Department/ Agency Sponsor point of contact
- ❸ Performers Database - contains information regarding Performer point of contact

There exists a one-to-many relationship between a project and a sponsor and performer. In essence, for each project there should exist at least one sponsor and one performer.

2.0 Getting Started

This chapter outlines the system requirements need for running the Environmental Sciences Research & Development Database (ESRD DB) and explains how to install the application.

System Requirements

- 80386SX processor (or higher)
- Mouse
- 4 MB RAM
- Microsoft Windows version 3.1 or higher
- VGA or higher resolution monitor recommended
 - it is recommended that the display be set at Super VGA (800 x 600, 256 colors, small fonts)
- 4 MB free hard disk space

Installation

To install the UVC DB:

1. Start up Microsoft Windows.
2. Insert Disk 1 into the appropriate drive and choose the **Run...** option from the Windows Program Manager **File** menu.
3. In the Run dialog **Command Line** box, type *a:\setup* then press ENTER.
4. Once Setup has initialized, the Select Installation Directory and Group dialog appears with a default drive path and a Windows program group already specified. The title on this dialog box will be *Environmental Sciences R&D Database (v1.0)*.
5. The application will be installed in a new program group named *ESRD DB*. To change the drive or path name, type the new drive or path name in the **Path** text box. To change the specified program group, choose the appropriate group from the **Program Manager Group** popup. If you choose **-None-** in the **Program Manager Group** popup, no program group or icon is created.

When the installation path and workgroup are set the way you want them, click **Continue** or ENTER to continue installation.

6. Once installation is complete, press ENTER to exit the setup.
7. To start the ESRD DB application, double-click on the ESRD DB v1.0 icon.

Updating Databases

The ESRD DB databases can be updated with more current databases from the Environmental Sciences R&D Database Data Entry Module. To implement the updated databases in the ESRD DB, copy the following files from the Data Entry Module Directory into the ESRD DB directory.

- | | |
|------------|----------|
| • proj.dbf | proj.cdx |
| • spon.dbf | spon.cdx |
| • perf.dbf | perf.cdx |

Support

If you have any questions regarding this application, please contact:

Mr. Ken Keasler
BDM International, Inc.
4001 N. Fairfax Dr., Suite 750
Arlington, VA 22203

3.0 Using the Environmental Sciences R&D Database (ESRD DB)

To execute the Environmental Sciences R&D Database (ESRD DB), follow the instructions in the **Installation** section of Chapter 1.0.

The first screen you will access after initiating the ESRD DB is the Introduction Screen, see Figure 3-1. This screen provides information regarding the development and purpose of this database and gives you the option to proceed by selecting **Query...** or **Exit** to exit the application. Selecting **Query...** will take you to Query Screen.

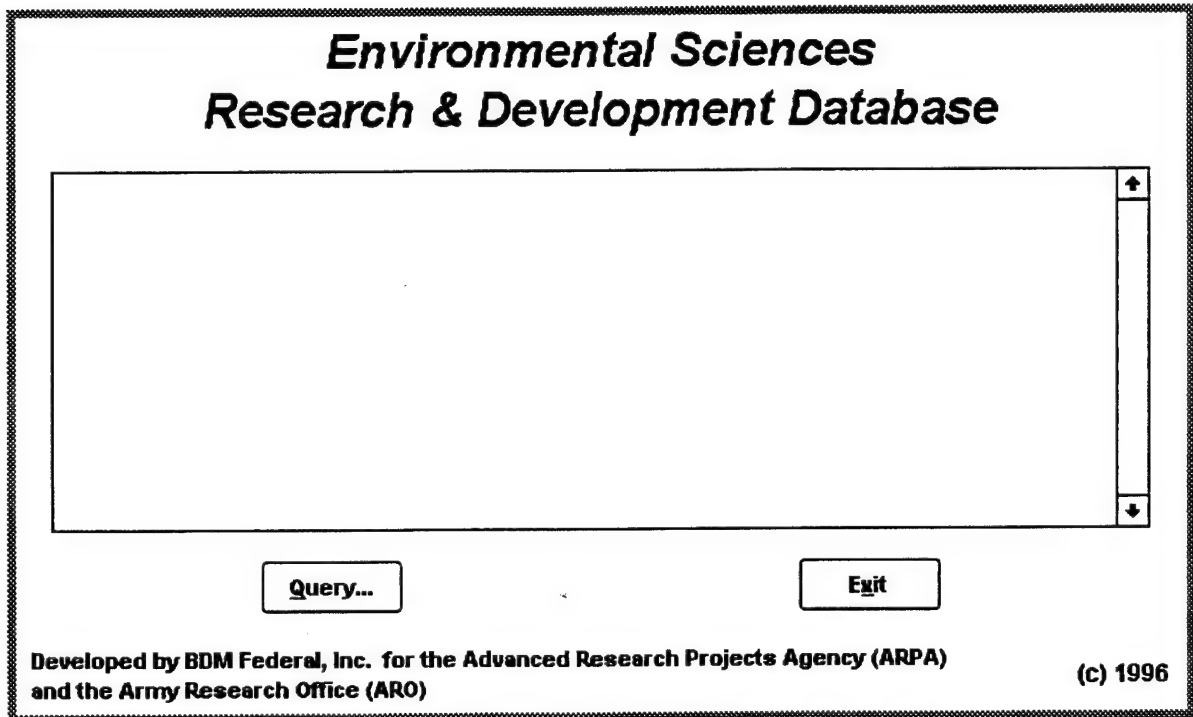


Figure 3-1: Introduction Screen

Database Query

When you select to query, you will be able to query the database, view the results in a summary form, and view a detailed record of the results. To perform a query, enter your search parameters using either the pull-down menus or text fields. Entering search criteria into the Department/Agency Sponsor or Performers areas of the Query Screen, Figure 3-2, will yield matching project records. The search engine of this application works on the assumption that there exists at least one sponsor and one performer for each project. If no search parameters are entered, the search will retrieve all of the complete project records. Additionally, the text fields are not case sensitive.

To move between the text fields and pull-down menus, use the **Tab** key or the mouse to click on the next field. The Material Types, Major Category, Potential Applicability, Stage of Development, Environmental Media, and Project Status fields are pull-down menus which are used in the same manner as standard Windows menus.

After you have entered in your search parameters, select the Search push button to start the search. The Clear Variables push button will clear any data from the search parameter fields. The About... push button will take you to the Introduction Screen. You may exit the application from by selecting the Exit push button.

Query

Project Name

Program

Principal Objective(s)

Keyword OR OR

Specific Materials OR OR

Material Types (Select From List) Major Category (Select from List)

Potential Applicability (Select from List) Stage of Development (Select from List)

Environmental Media (Select from List) Project Status (Select from List)

Information Source Funding

DEPARTMENT/AGENCY SPONSOR **PERFORMERS**

Sponsor Organization

POC Last Name POC Last Name

Figure 3-2: Query Screen

Complete information regarding project name, program, or principal objective is not required to identify any matching project records. A single word or multiple-word phrase provides a sufficient basis for locating records potentially of interest. If no matching project records are found, the screen in Figure 3-3 is displayed. Selecting Continue... returns you to the Query Screen where you can modify your search parameters.

**No Matching
Project
Records Found!**

Figure 3-3: No Matching Records Screen

Query Results

The results of the query are displayed in a list on the Results Screen, see Figure 3-4. The list allows you to scroll through either the project names. The number of matches to your query are also displayed. To view a full record, highlight the item in the list and select the View Record push button. This will place you in the first output screen where you can view the contents of the project record. To modify your query, select the Modify Query push button.

Number of Matches:

Project Name

Figure 3-4: Results Screen

Project Information

The full record for each project is divided between two screens, see Figures 3-5 and 3-6. After selecting the record to view from the Results Screen, you will be positioned at the Project Information - Part 1 of 2 Screen. To move to the next project screen, select the Continue... push button. The Modify Query push button will take you back to the Query Screen. The View Results push button will take you back to the Results Screen. The Prev Record and Next Record push buttons allow you to toggle between the previous and next records.

Program

Principal Objective(s)

Project Deliverables

Keywords

Material Type(s) ☐ Metals ☐ Ceramics ☐ Organics ☐ Composites ☐ Inorganics ☐ Solvents ☐ Other

Specific Materials

Major Category ☐ Cleanup/Remediation ☐ Compliance ☐ Pollution Prevention ☐ Char/Monitoring
☐ Conservation ☐ Global Env. Change ☐ Alternate/Clean Energy ☐ Life Cycle Analysis

Environmental Media ☐ Soil/Sediments ☐ Air ☐ Ground Water ☐ Surface Water ☐ Buildings/Equipment

Figure 3-5: Project Information - Part 1 of 2 Screen

In the Project Information - Part 2 of 2 Screen, the **S**ponsors push button will take you to the Department/Agency Sponsor Screen and the **P**erformers push button will take you to the Performers Screen. The **M**odify Query push button will take you back to the Query Screen where you can modify the current search or clear variables prior to executing a new search. The **V**iew Results push button will take you back to the Results Screen. The **R**eturn push button will take you back to the Project Information - Part 1 of 2 Screen.

Stage of Development ☐ Proof of Principle ☐ Field Demonstration ☐ Lab/Bench Scale ☐ Approaching Deployability

Potential Applicability ☐ Materials Selection ☐ Manufacturing ☐ Reuse/Recycling
☐ System/Component Design ☐ Use ☐ Storage/Disposal
☐ Materials Handling ☐ Maintenance ☐ Not Apparent

Summary Description

Period of Performance

Funding

Status ☐ Active ☐ Pending ☐ Proposed ☐ Other **Comment**

Information Source

Info Entry By **Entry Date** **Revised By** **Revision Date**

Sponsors **Performers** **Modify Query** **View Results** **Return** **Exit**

Figure 3-6: Project Information - Part 2 of 2 Screen

Department/Agency Sponsor Information

The department/agency sponsor information is displayed in Figure 3-7. The **R**eturn push button will take you back to the Project Information - Part 2 of 2 Screen. The **P**rev Record and Next **R**ecord push buttons allow you to toggle between the previous and next records.

Department/Agency Sponsor	
Sponsor	<input type="text"/>
Point of Contact Information	
Name	<input type="text"/>
Title	<input type="text"/>
Organization	<input type="text"/>
Phone	<input type="text"/>
Fax	<input type="text"/>
E-mail	<input type="text"/>
<div>Prev Record</div> <div>Next Record</div> <div>Return</div>	

Figure 3-7: Department/Agency Sponsor Screen

Performers Information

The project performers information is displayed in Figure 3-8. The **Return** push button will take you back to the Project Information - Part 2 of 2 Screen. The **Prev Record** and **Next Record** push buttons allow you to toggle between the previous and next records.

Performers	
Organization	<input type="text"/>
Address	<input type="text"/>
Point of Contact Information	
Name	<input type="text"/>
Title	<input type="text"/>
Phone	<input type="text"/>
Fax	<input type="text"/>
E-mail	<input type="text"/>
<div>Prev Record</div> <div>Next Record</div> <div>Return</div>	

Figure 3-8: Performers Screen

Printing

There are two printing options in this application: *Print This Record* and *Print All Matching Records*. Selecting *Print This Record* will print only the record that you are currently on; selecting the *Print All Matching Records* option will print all the records from the query results list (all records that matched your query). The print options are found in the **Print** pull-down menu. The **Print** pull-down menu appears as an added pull-down menu on the system menu bar upon entering the ESRD DB application. This menu is enabled from Project Information - Part 1 of 2 and Project Information - Part 2 of 2 screens.